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Report

Targeted Conservation to Safeguard a Biodiversity Hotspot from Climate and Land-Cover Change

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Summary

Responses of biodiversity to changes in both land cover and climate are recognized [1] but still poorly understood [2]. This poses significant challenges for spatial planning as species could shift, contract, expand, or maintain their range inside or outside protected areas [2–4]. We examine this problem in Borneo, a global biodiversity hotspot [5], using spatial prioritization analyses that maximize species conservation under multiple environmental-change forecasts. Climate projections indicate that 11%–36% of Bornean mammal species will lose ≥30% of their habitat by 2080, and suitable ecological conditions will shift upslope for 23%–46%. Deforestation exacerbates this process, increasing the proportion of species facing comparable habitat loss to 30%–49%, a 2-fold increase on historical trends. Accommodating these distributional changes will require conserving land outside existing protected areas, but this may be less than anticipated from models incorporating deforestation alone because some species will colonize high-elevation reserves. Our results demonstrate the increasing importance of upland reserves and that relatively small additions (16,000–28,000 km^2) to the current conservation estate could provide substantial benefits to biodiversity facing changes to land cover and climate. On Borneo, much of this land is under forestry jurisdiction, warranting targeted conservation partnerships to safeguard biodiversity in an era of global change.

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Results and Discussion

Conservation planning tools can help evaluate protected area effectiveness under climate change [6], advocate new reserves for range-shifting species [4, 7], and incorporate climate adaptation into national assessments [8]. Yet, because few analyses also incorporate the biodiversity impacts of other anthropogenic threats, the ultimate planning needs for environmental change could be underestimated, leading to ineffective targeting of limited conservation resources [2, 4].

Our spatial analyses account for the effects of different climate and land-cover change forecasts on multiple tropical taxa. Borneo ranks among the most vulnerable biodiversity hotspots [9] and exemplifies many of the challenges facing conservation planning [5, 7]: biodiversity decline is predicted by global climate analyses [10] and high rates of habitat loss [11], and reliable distribution data are difficult to obtain. To undertake our assessment, we assembled a comprehensive distribution dataset of 81 mammal species (6,921 records of 13 primate, 23 carnivore, and 45 bat taxa) and developed a framework to model the extent of suitable habitat for each species, utilizing projected climate and land-cover data independently or additively. We identified areas of highest conservation value that could consistently meet minimum areal targets for each species following forthcoming environmental change. To minimize risk of commission and omission errors in our predictions (i.e., a species mistakenly thought to be present or absent, respectively), we accounted for potential sampling bias and incorporated models based on different climate data and presence thresholds, resulting in up to eight possible suitability maps for each species in each time slice (4,698 species-specific maps).

Changes to Suitable Habitat

Although our results demonstrate species-specific responses to environmental change, tracking the extent of suitable habitat between 2010 and 2080 reveals net declines for many species (Figure 1A). When considering climate projections alone (keeping land cover fixed to 2010 conditions), 11%–36% of Borneo's mammal species could lose ≥30% of their 2010 habitat by 2080, a trend consistent for each taxonomic group assessed (Figure S2). While comparable losses via land-cover change are not predicted until the end of this century (2%–9% of species by 2050; 26%–41% by 2080), declines will be exacerbated by both processes acting together, resulting in 11%–40% of species losing ≥30% habitat by 2050 and 30%–49% by 2080. This suggests that at least 14 carnivore, 4 primate, and 11 bat species could face a heightened risk of extinction by 2080 (http://www.iucnredlist.org) (Table S3), almost doubling the proportion of threatened mammals on the island. Habitat loss calculations derived from projections hindcasted to a time before major environmental changes (ca. 1950s) indicate that 16%–26% of species have already been exposed to comparable habitat loss, suggesting that the number of Borneo species affected by projected future changes could be almost double that of the recent past.